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THE ROLE OF COLOR IN LEARNING AND INSTRUCTION.

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Research on the function of color in instruction and learning is reviewed, and the rationale for its use in instructional materials and as an aid to learning is examined. Three points are made: (1) on the basis of research results, it is not yet possible to prescribe the use of color cues in instruction; (2) color is presently being used in instructional materials only as a means of carrying basic information, not as an additional cue to enhance learning; and, (3) the cue value of color depends on the availability of a variety of other more potent cues. It is implied that the nature and extent of interaction among differing ages, abilities, skill development, color cues, and other available cues should be further clarified. (Author/NS)

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THE ROLE OF COLOR IN LEARNING AND INSTRUCTION

REPORT FROM THE READING PROJECT

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THE ROLE OF COLOR IN LEARNING AND INSTRUCTION

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Report from the Reading Project

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PREFACE

This theoretical paper is one product of the reading project with Program 2, Processes and Programs of Instruction, of the Wisconsin Research and Development Center for Cognitive Learning. The focus of Program 2 is to improve educational practice through the application of knowledge to instructional problems within disciplines such as reading.

In line with the general objective of the reading project, to clarify the relationships among reading task variables and reading achievement, this report deals with the role of color in instruction and learning. The intent of this paper is to review existing research related to the use of color cues in instruction. Theoretical papers such as this exemplify the overall purpose of the R & D Center of contributing to the understanding of cognitive learning by children and youth and the improving of educational practice related to such learning.

Thomas A. Romberg
Director, Program 2

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ABSTRACT

Recently publicized schemes for using color in instruction, particularly the teaching of reading, has brought about a refocusing of attention upon this specific application of color in education. Yet researchers have long been interested in the role of color in the general area of learning and a sizable body of literature exists. The purpose of this paper was to review the existing research relating to the function of color in learning, to examine the rationale for present applications of color in instructional materials and to consider the implications regarding the use of color as an aid to learning. Three basic points were made. (1) On the basis of existing research results it is not yet possible to prescribe the use of color cues in instruction. Research designed to clarify the interactions among a variety of cues with diverse populations must first be clarified. (2) Color is presently being used in instructional materials not as an additional cue to enhance learning but as a vehicle for carrying basic information. There have been no real attempts to apply research results regarding the cue value of color in learning to instructional materials. (3) The cue value of color appears to be rather nebulous, being dependent upon the availability of a variety of other, more potent cues.

THE ROLE OF COLOR IN LEARNING AND INSTRUCTION

In recent years the publicity given to schemes for using color in the teaching of reading has caused much attention to be focused upon this specific application of color in education. Researchers have, however, long been interested in the role of color in the general area of learning, and a sizable body of literature exists. The purpose of this paper is to review the existing research relating to the function of color in learning, to examine the rationale for present applications of color in instructional materials, and to consider the implications regarding the use of color as an aid to learning.

RESEARCH THEMES

Two general themes can be identified in the research related to color in learning: Studies of color in concept attainment and studies of color as a contextual cue, particularly in paired-associate learning.

Color in Concept Attainment

In the concept attainment or problem solving area, several different experimental approaches have been employed. The studies reviewed are grouped by approach.

A set-up similar to that used by Harlow in his work with primates was employed in one group of studies. Calvin and Clifford (1956) taught first-grade subjects which of two cups contained a toy by rewarding the "correct" choice between the cards displayed above each cup. The subjects had more difficulty choosing between colors than between different brightness levels of the same hue, patterns, or achromatic stimuli. House and Zeaman (1963) found that after both color and form in the stimulus had been rewarded in early trials, form tended to be preferred slightly but consistently over color when both dimensions were no longer rewarded. They also reported that children with higher MAs tended to treat form and color as a compound or to rely more upon the form component. The same researchers (Zeaman and House, 1963) found that when mentally retarded subjects had to discover the relevant dimension (e.g. color, form) and the relevant cue within the dimension (e.g., "red" within the color dimension) of a stimulus to receive a reward, objects differing only in color presented the most difficulty.

In another approach, the aim was to determine the order in which certain concepts were attained. Heidbreder, Bensley and Ivy (1948) gave their adult subjects an ostensible memory task—the subjects were told to memorize nonsense words in association with colored geometric forms or concrete objects—which actually required recognition of the concept of color, form, or number in the stimulus for success in anticipating the correct nonsense syllable. The concepts were attained in an order moving away from the "thing-character" of the concept: concrete object, geometric form, color, and finally number. However, when the experiment was run without using numbers, Heidbreder and Overstreet (1948) found that the position of color shifted in the order of attainment, falling between concrete objects and geometric forms. In another series of experiments, in which a card sorting task was employed, Heidbreder (1949) obtained results that were similar to those in her earlier experiments when the task became more difficult (e.g., when the concept of number was included). However, order of attainment varied when cues were abundant and the task was easier. Grant, Jove, and Tallantis (1949) and Grant and Curran (1953) also employed a card sorting task to study the relative difficulty of number, form, and color concepts. The largest numbers of sorting errors were made when color was the relevant cue.

Numerous studies have been done to establish form/color preferences in matching tasks. The most common task, developed by Descoeudres (1914), entails having the subject choose

one of two different objects as matching a third, the standard, which differs from one object only in color and from the other only in form. Conflicting results have led to conflicting notions about the bases for form versus color preference matching.

One notion is that preference is a function of both physical and intellectual development. Matching on the basis of color is considered the most primitive response, whereas perception of form is considered a more highly developed concept because it requires selection of details from field (Schachtel, 1959). The early studies of Tobie (1927) in Germany, Descoeurdes (1914) in France, and Brian and Goodenough (1929) in the United States revealed a preference for color matching between the ages of three and six and a preference for form matching after that age period. Colby and Robertson (1942) obtained similar results. When they retested subjects one year after initial testing, they found that all age groups showed an increase in matching by form. Interestingly, Goldstein and Scheerer (1941), using the Weigl-Goldstein-Scheerer (WGS) Color Form Sorting Test with brain-injured subjects, observed that "aments" (subjects with undeveloped intellect) preferred color in sorting while "dements" (subjects with developed intellect) preferred form, which appears to demonstrate a consistent tendency to move from color to form sorting with development.

Other researchers, however, have either obtained conflicting results or drawn different conclusions from similar results. Doehring (1960), using matching tests with both deaf and hearing preschool children and with hearing adults, found no significant age differences in form/color preferences. He did, however, note two differences: More males preferred color, although a sex difference was not reported in the studies cited above; and more deaf children preferred color. Interestingly, Larr (1956) found no significant form/color preference differences between deaf and hearing children in three different parts of the country. Other investigators have found, like Doehring, sex differences. Honkavaara (1958) found that more girls between the ages of seven and eleven preferred form. Kagan and Lemkin (1961), whose subjects were in the three to nine age range, found that younger girls matched on the basis of color more often than older girls, that older boys used color more often than older girls, but that there were no significant differences in the preferences of older and younger boys.

Corah (1964) found no significant sex differences; but he did find a highly significant age difference ($p < .001$), which he explained in terms of Piaget's concept of centration. That is, while a young child would attend only to the dominant characteristic of a configuration, i.e. color, an older child, whose perception is decentered, would be free to attend to all characteristics, including form. In a later study, Corah, Jones, and Miller (1966) found no significant relationship between form/color preference and IQ, which amounts to a refutation of earlier suggestions that form preference is related to intellectual as well as physical development; but they also noted that subjects who preferred form on matching tasks were able to discriminate both form and color significantly better on other tests, which they felt was evidence of increased perceptual decentration. Corah (1966) also reported a study in which the hypothesis was that the degree of color matching is a function of the complexity of the stimuli employed. The finding was that preschool subjects gave more color responses regardless of form complexity.

Another group of researchers has tended to dismiss the developmental hypothesis in explaining their results with regard to form/color matching. Gaines (1964), who found that 55% of her deaf subjects and only 23% of her hearing subjects preferred color over form in matching tasks, also found that when the same subjects were asked to discriminate among slight variations in color and form, the deaf subjects could discriminate color significantly better than hearing children and the hearing subjects could discriminate form better. Thus, the deaf subjects' preference for color and the hearing subjects' preference for form was related to the discrimination ability of each group. Suchman and Trabasso (1966b) obtained similar results. When their subjects, whose form/color preferences were determined with a preliminary task, were given a card sorting task, learning was facilitated or retarded depending on whether or not the cues in their preferred dimension, color or form, were relevant. Suchman (1966a) also reported that hearing subjects preferred form and deaf subjects preferred color and that each group did better with discrimination learning in the preferred dimension. The cause-effect relationship is obscure; that is, whether ability to discriminate leads to preference or preference results in sharpened discrimination ability is unknown, but it does seem clear that personal preference for color is related to performance with color.

There is evidence, too, that certain environmental influences have an impact upon form/color preference. Lee (1965) pointed out that

his subjects' decreasing use of color as a basis for matching at about age six may have been a function of the educational system, in which the introduction of reading instruction causes attention to be focused upon form at about that age. Recognizing this possibility and the fact that the existing research had been done in countries where reading instruction does in fact begin at about age six. Suchman (1966b) gave several matching tasks to Moslem Hausa children ranging in age from three to fifteen in Zaria, Nigeria, and West Africa. Of the 357 test scores obtained, only 24 from all age groups indicated a preference for form and no single subject selected form on all tests. Thus, Suchman dismissed the developmental hypothesis as an explanation for the transition from color to form because the transition is not universal. She speculated that color preference may be implicitly rewarding to deaf children and to people from a culture where form is not stressed as an important cue.

Finally, Suchman and Trabasso (1966a) found that form/color preferences remained stable even when unsaturated as well as saturated hues were presented in the color dimension and asymmetrical shapes were presented in the form dimension. On the other hand, Huang (1945) found that the nature of objects partially determines the basis of children's choices. Using toy dresses, folded paper representing different objects, and plane geometric figures—all of which varied in both form and color—he found that 0, 100 and 75% of the choices were made on the basis of form with each respective group of objects.

Color as a Contextual Cue

Studies of color as a contextual cue generally have been done in a paired-associate learning framework.

In an early tangentially related study, Pan (1926) had his subjects associate names and faces presented on picture postcards and found that they made more recall errors when the postcard backgrounds were different than when they remained the same. Later, Dulsky (1935) had subjects learn pairs of nonsense words presented on two types of backgrounds: homogeneous, with a different color for each pair or the same color for all pairs, and heterogeneous, with the stimulus half of each card colored and the response half gray and vice-versa. Learning was followed by recall under three conditions: replication of the learning conditions, interchange of colored backgrounds, and change to all gray backgrounds. Recall was most accurate when the gray stimulus backgrounds and colored response backgrounds remained the same as in the learning trials. The learning decrement was greater when response background colors were changed than when stimulus or total backgrounds were changed. Weiss and Margolius (1954) noted that responses can be associated not only with the primary stimulus but also with one or more contextual stimuli, which may enhance both learning and recall/relearning. They presented subjects with pairs of nonsense trigram stimuli and simple word responses on different colored cards and found retention under varied conditions to be arranged in the following descending order: no change in stimuli or colored backgrounds; slight modification of stimuli, e.g. a square to a rectangle; no change in stimuli but change in colors; and change in both stimuli and colors. The Weiss and Margolius procedure has served as a prototype for subsequent research designed to determine the functional component in paired-associate learning.

Underwood, Ham, and Ekstrand (1962) found that subjects could not recall a list of low meaning trigrams which had originally been learned on different colored cards, but when meaningful words were learned instead of low meaning trigrams the words were retained after the color cues were removed. The interpretation was that with unfamiliar trigrams, familiar colors became the functional stimuli; but because the adult subjects were more accustomed to responding to words than to colors, the familiar words were the functional stimuli. Jenkins and Bailey (1964) attempted to control cue selection in a study that was a replicate of the Underwood, Ham, and Ekstrand study with the exception that the subjects were asked to spell out the trigrams and to name the colors; but these additional activities had no significant impact upon performance. In reaction to the cue selection notion, Saltz (1963) alternated learning and test trials and presented color cues only during learning or only during testing. The provision of color cues enhanced performance in both conditions, and he concluded that cognitive differentiation had occurred during the learning trials and sensory differentiation had occurred during the testing trials. Hill and Wickens (1962) reasoned that the form and color components of a stimulus might summate to evoke a response whereas either presented singly would not; and they speculated about whether the components should be learned together or separately and then combined. They had subjects learn nonsense word/color-common word pairs in a nonanticipation sequence in which pairs were presented together in learn-

ing trials and stimuli were presented alone in the alternate testing trials. The following setups were used: (1) each stimulus component was learned and tested separately and then the components were combined for final testing; (2) each component was learned and tested separately and the final tests covered only the most recently studied component; (3) the two components were combined for all trials; (4) each component was learned and tested separately and they were never combined. The best results were attained by the subjects who learned the components separately and then responded to a combination in final testing. Because many subjects responded correctly to only one component before a combination was formed, the researchers rejected the summation theory. They concluded that two cues were more helpful than one because each subject was free to choose his functional stimulus.

Furth and Youniss (1964) taught deaf and hearing children to associate cards of a neutral or inappropriate color with toys (e.g., inappropriate, white with a fire engine when a white refrigerator is also present) and found that the hearing subjects were more affected by the interference. They reasoned that perhaps the deaf subjects lacked sufficient verbal (mediational) skills of experiential backgrounds to realize that the associations were incompatible. Birnbaum (1966), alternating study and test trials in paired-associate learning, provided secondary color cues on the study trials only. After intervening tasks, she presented half of her subjects with the same task and the others with the same stimulus-response pairs but different secondary color cues. The latter group did less well on the posttest in spite of the fact that the stimulus-response pairs were unchanged. Crannell (1964), using black-and-white or colored stickers associated with a letter, numeral, or simple word, concluded that color cues were not useful in this task because it was too easy; that is, differentiation on the basis of color occurs mainly in more difficult learning tasks. Sunderland and Wickens (1962) also concluded that context cues are not used when the primary stimuli are highly discriminable. They found that color did not significantly facilitate learning either simple words or nonsense syllables; yet, when color was removed on transfer trials, the subjects made more errors on the nonsense syllable list but performance on the meaningful word list did not change. However, when the primary stimuli were removed performance on the nonsense syllable list was not affected, indicating that color was the functional stimulus, while performance on the meaningful word list dropped off significantly. Newman and Taylor (1963) found that secondary color cues were used more when the primary stimuli were highly similar. They taught four groups of subjects either high similarity or low similarity lists on colored cards and presented either the same color cues or no color cues on transfer trials. Performance deteriorated most among the subjects who had learned the high similarity list and then were deprived of color cues on the transfer trials.

COLOR IN INSTRUCTIONAL MATERIALS

Color has been used in instructional materials primarily in the area of reading, although Lea (1966) has described the use of color in teaching parts of speech and sentence patterns to aphasic children. In general, no real attempt has been made to draw upon existing research and theory regarding the role of color in learning; instead color has simply been used as an added, information bearing cue. Consequently, the current literature includes descriptive rather than experimental reports, although a study by Jones (1965) is a notable exception.

Jones examined the value of color as an aid to visual discrimination of words and letters among nursery school children. He reasoned that nursery school children are old enough to take visual matching tests but too young to have acquired reading habits that would influence their responses. The task comprised a pair of matching tests, one in black and one with color, of six English reversal letters (p, q, u, n, d, b) followed by a second pair of matching tests in black and with color of six English words transposed into an unfamiliar script to control for learned reading responses. On the basis of the data, Jones concluded that without color the task was "at least three times" as difficult as with color, even when possible color matching was considered. Furthermore, he noted that the subjects strongly preferred the colored test materials. The implication seems to be that color may have value both as an aid to discrimination and as a motivational device in early reading.

Gattegno has devised a "morphologico-algebraic" approach to teaching reading in which color is such a salient feature that the approach has come to be called Words in Color. [The focus here upon the use of color amounts to an unintended oversimplification; the reader is referred elsewhere (Gattegno, 1962; Gattegno and Hinman, 1966; Leonore, 1965) for an overview of the total approach.] In the approach color is used primarily to bring sound/

symbol regularity to the notoriously irregular English language (e.g., the qu combination is shown in a single color, gold, when there is a single sound as in liquor, but in two colors, gold and aqua, when there is a double sound as in quickly; s, ss, 's is green when associated with the sound in sat, but purple when associated with the sound in is). To encourage pupils to attend to shape as well as color, easily confused letters are presented in similar colors (e.g., d and b are in shades of green). Color, then, is not a secondary cue; instead, it is an integral information bearing part of the system. The function of color in the Words in Color approach is the same as that of the added symbols in the i/t/a (initial teaching alphabet) approach. Bannatyne (1966) has devised a "color phonics system" for teaching reading to dyslexics that differs in detail but is similar in principle to Words in Color.

Although there have been others, the Gattegno and Bannatyne efforts seem to exemplify teaching approaches in which color has been used. As already pointed out, color has been used to carry basic information. Little has been done to make use of the existing research results, probably because the implications regarding the cue value of color in children's learning remain essentially unclear.

A LINE OF RESEARCH AND IMPLICATIONS

The studies reviewed here were initially undertaken in an attempt to determine the usefulness of color cues with good and poor readers. This seemingly straightforward goal has proved to be quite elusive, but the hope is that some progress has been made.

The purpose of the first study (Otto, in press$_a$) was to determine (1) whether children's paired-associate learning would be enhanced by the provision of color cues and (2) whether any facilitative effect would differ for good and poor readers. An implication of existing studies is that children's paired-associate learning ought to be enhanced by the addition of color cues due to aided perception and differentiation, increased opportunities for cue selection, mediation, increased motivation, or some combination of these. And, logically, the poor readers were expected to benefit more from any facilitative effect due to their apparent need for cues in addition to the forms presented in the paired-associate task.

Seventy-two pupils in Grades 2, 4, and 6 learned a list of five geometric form-trigram pairs. Half of the subjects learned the list in black and white and half learned the list with each pair in a distinctive color. The poor readers required more trials to learn the list and trials required decreased as grade level increased, but the addition of color cues had no significant overall effect. Although the trends did not reach acceptable significance levels, good readers tended to benefit more than poor readers from the color cues and the trend was for increasing benefit with increasing grade level; thus, they were opposite to the reasonable expectation that less sophisticated learners would benefit more from the provision of additional cues. Some possible explanations for the absence of a significant color effect were suggested: the geometric forms in the list were so dissimilar that further cues were not particularly useful—this is in line with previous findings that color cues enhance learning only when intralist similarity is high; the effect of presenting both the stimulus and response items in each pair in a single color may have been to decrease the salience of the color cue; there was subjective evidence that the subjects were unaware of the systematic use of color in the task.

The decision, then, was to run a second study (Otto, in press$_b$) with a more reading-like paired-associate task, increased intralist stimulus similarity, and explicit mention of the use of color before learning. The basic question was whether performance would be enhanced by the provision of color cues with the revised setup. Again, the 72 subjects were equal numbers of good and poor readers from Grades 2, 4, and 6. The list comprised six three-letter words written in Greek letters as stimuli and common English words as responses. Each stimulus was presented in black and white or a distinctive color and the responses were oral; thus, the task was similar to sight word learning in reading. As in the first study, the list was learned to a criterion of correct anticipation of the entire list first with serial and then with scrambled presentation.

The poor readers took more trials to learn the list and trials required decreased as grade level increased; but with the revised conditions the color cues significantly enhanced learning and, also contrary to the first study, some of the subjects required markedly fewer trials with the scrambled presentation that followed the serial presentation. The latter suggests that some of the subjects were using serial order of presentation as a cue, which is in line with the suggestion by Samuels and

Jeffrey (1966) that serial presentation is superior to scrambled when intralist similarity is high because, in effect, the constant order permits more efficient differentiation among similar stimuli. Furthermore, the trend in this study was for second graders to make more use of the color cues and there was no apparent trend on the basis of reading ability.

The implication appears to be that both the nature of the list, specifically intralist similarity, and the order of presentation may be significant determiners of the usefulness of color cues in paired-associate learning. That is, with greater stimulus similarity the need for and use of further stimulus differentiation or outright cue selection (i.e. substitution of the secondary color stimulus for the primary stimulus) increases; but, at the same time, serial presentation enhances learnihg when similarity is high but has no effect when similarity is low. There was evidence of interaction among degree of intralist similarity, order of presentation, and color; but the design of the study did not permit examination of an interaction as such. There was no support for the notion that color cues would have a more facilitative effect with poor readers.

The final study—in what has turned out to be a series of studies—completed to date was done to examine the relative roles of and possible interactions among intralist similarity, order of presentation and color in children's paired-associate learning (Otto, in press$_C$).

A high similarity list, six words made up from three Greek letters arranged in all possible three-letter combinations, and a low similarity list, six three-letter words made up from 18 nonrecurring Greek letters, were prepared to serve as stimuli; responses were spoken three-letter English words. Each list was printed in black and six distinctive colors. The four resulting lists were presented in serial or scrambled order to equal numbers of second graders and learned to a criterion of two successive anticipations of the entire list or 15 trials. One postcriterion trial in which the nature of the list and the order of presentation were systmatically changed, e.g. color to black or serial to scrambled, was given.

Analysis of variance of precriterion performance revealed significant effects of intralist similarity and order of presentation and an interaction between them, but there was no significant color effect. The interaction analysis showed that the subjects who learned the high similarity list in scrambled order required more trials than all other subjects. Yet, analysis of the postcriterion performance deteriorated significantly, as it did when serial order was changed to scrambled. The suggestion was that color appears to be a less potent cue than serial order, at least among second graders, but there is evidence of color cue selection.

The salient implication of all the existing research seems to be that the cue value of color is fragile at best and apt to be superseded by more potent cues. On the other hand, color cues appear to be better than no cues at all, and it would be sensible to provide them when stimuli are so similar or so unsystematically presented as to provide little basis for differentiation. Yet, there is reason to believe that pupils' age (or grade, or developmental stage) is critical in determining color cue value, so what works at one level may not work at another. The picture that emerges at this point is still not clear, and whether it can be brought into focus remains to be seen.

One important question that needs a more definitive answer before sound judgments can be made about the pragmatic value of secondary color cues in instruction is whether enhanced learning with color results simply from cue selection or, at least in part, from improved differentiation of primary stimuli. The issue is vital because, as an example, in teaching sight words the use of color would have a salutory effect upon reading ability if the colors were useful for purposes of differentiation, but no useful purpose would be served if colors instead of words became the functional stimuli. The question seems straightforward enough, but the lack of agreement among researchers on the cue selection-differentiation issue has already been noted. While cue selection is easy to detect, the quantification of the residual effects of increased differentiation presents problems that are likely to be confounded by the age/grade/development level of pupils and the availability of other cues.

Other questions also need to be considered if color cues are to get an optimum tryout. For example, would color cues be most useful if individuals were permitted to pick their preferred colors? The existing research seems to suggest that children's preference for form or color is an important determiner of performance with either type of stimuli; perhaps if children were permitted to choose their preferred colors as cues there would be a greater tendency to make optimum use of the cues. Would color cues be of maximum usefulness at the pre- or beginning reading stages before children make the shift in attending to form rather than color? Or, if they found color cues to be useful early in the instructional sequence, perhaps they would not make a shift but make maximum use of both. In what particular stimulus array and

with which particular groups, if any, are color cues useful? It seems clear that color cues tend to be most useful when other cues are minimal, but much of the existing confusion seems to arise from the fact that different age/ability/skill development groups respond differently to available cues. Further clarification of the nature and extent of interactions will be useful.

To sum up, at the present time the use of color cues in instruction cannot be very explicitly prescribed. Although the promise of better things is not without reservation, the fact seems to be that the use of color in instruction has never had a truly fair trial. The latter appears to be so because the relevant variables have not been identified and considered. Some directions have been suggested.

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